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Summary

A metabolism experiment was conducted to evaluate rumen pH, digestibility, and in situ *nutrient disappearance in steers fed either a diet containing 95% corn silage or diets containing 15 or 45% corn silage and 20 or 40% modified distillers grain with solubles (MDGS). Steers fed 45% compared to 15% corn silage had increased ruminal pH, DMI, NDF intake, and NDF digestibility. Decreased DM and OM digestibility were observed in diets containing 40% MDGS compared to 20%. Disappearance of corn bran NDF was increased in diets containing 45% corn silage. These results imply enhanced fiber digestibility as diets increased in corn silage.*

Introduction

The use of corn silage in beef finishing diets has been shown to be economical in times of high priced corn. In three experiments (*2013 Nebraska Beef Cattle Report*, pp. 74-75; *2014 Nebraska Beef Cattle Report*, pp. 88-89; *2015 Nebraska Beef Cattle Report*, pp. 66-67) with corn silage inclusions of 15% to 45% of the diet in finishing diets containing distillers grains, ADG and F:G were poorer as corn silage inclusion increased. In these experiments with diets containing MDGS, corn silage had a calculated feeding value of approximately 83% that of corn, which is far greater than the 48% feeding value for corn silage calculated from performance for steers fed 15 to 45% corn silage in diets without distillers grains (*2000 Nebraska Beef Cattle Report*, pp. 68-71). As well, economic analysis has determined that despite poorer F:G, feeding increased concentrations of corn silage in the diet was economical when fed with MDGS in times of high priced corn (*2015 Nebraska Beef Cattle Report*, pp. 68-70). The objective of this trial was to compare digestibility and rumen metabolism of finishing diets containing corn silage and MDGS as partial replacements for corn grain.

Procedure

Six ruminally fistulated steers were used in a 5 × 6 latin rectangle experiment to determine diet digestibility of 5 diets. Steers were assigned randomly to five, 21-day periods. Periods consisted of a 15-day adaptation period and a 6-day collection period. Treatments were designed as a 2 × 2 + 1 factorial arrangement consisting of 15% or 45% corn silage and 20% or 40% MDGS (15:20 - 15% corn silage, 20% MDGS; 15:40 - 15% corn silage, 40% MDGS; 45:20 - 45% corn silage, 20% MDGS; and 45:40 - 45% corn silage, 40% MDGS) and a control diet consisting of 95% corn silage (Table 1). Elevated concentrations of corn silage and/or MDGS replaced dry-rolled corn. Diets were mixed twice weekly and stored in a cooler (32°F) to ensure fresh feed. All steers were fed a supplement formulated for 30 g/ton Rumensin (DM basis) and a targeted daily intake of 90 mg of Tylan. Urea was included at 1.66% (DM basis) in the control diet, 0.50% in diets containing 20% MDGS, and none for diets containing 40% MDGS.

Titanium dioxide was dosed at 5 g/steer twice daily at 0800 and 1600 hours for seven days before and during the collection period. Fecal grab samples were collected at 0800, 1200, and 1600 hours during day 1-5 of the collection period. Fecal samples were composited on a wet basis into daily composites and then freeze-dried. From daily composites, a steer within period fecal sample composite was prepared and subsequently analyzed for NDF, OM, and Ti concentration. Ruminal pH was recorded every minute using wireless pH probes (Dascor, Inc.; Escondido, Calif.) from day 1 to 5 of the collection period. Feeds offered and refused were analyzed for DM, OM, and NDF percentage. Dry matter of feed ingredients and orts were determined using a forced-air oven at 60°C for 48 hours.

An *in situ* study was conducted concurrently. Dacron bags (Ankom Techology, Fairport, NY) were filled with 1.25 g of as-is dry corn bran, dry-rolled corn (DRC), or corn silage. Four bags per feedstuff were placed in mesh bags and incubated in the ventral rumen of each of the 6 steers for incubation time periods of 24 and 36 hours. Bags were incubated

(Continued on next page)

Table 1. Diet composition (DM basis).

	Treatment[1]				
	Control	15:20	45:20	15:40	45:40
Dry-rolled corn	0.0	60.0	30.0	40.0	10.0
Corn silage	95.0	15.0	45.0	15.0	45.0
MDGS[2]	0.0	20.0	20.0	40.0	40.0
Supplement[3]	5.0	5.0	5.0	5.0	5.0

[1]15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]MDGS= Modified distillers grains with solubles.
[3]Three supplements were formulated for 30g/ton of DM Rumensin® and to provide a targeted daily intake of 90 mg/steer Tylan®. In the control diet, 1.66% urea was included in the diet. In diets containing 20% MDGS, 0.50% urea was included in the diet. No urea was included in diets containing 40% MDGS.

Table 2. Effect of corn silage and modified distillers grains with solubles (MDGS) inclusion on intake and digestibility of nutrients.

	Treatment[1]						P-value[2]			
	Control	15:20	45:20	15:40	45:40	SEM	F-test	Int.	Silage	MDGS
DM intake, lb/day	16.12[c]	21.59[b]	24.78[a]	22.02[b]	23.32[ab]	1.59	<0.01	0.40	0.07	0.69
DM digestibility, %	61.63[c]	72.52[a]	71.62[a]	70.42[ab]	66.78[b]	2.08	<0.01	0.47	0.10	0.04
OM intake, lb/day	15.08[c]	20.59[b]	23.37[a]	20.83[b]	21.82[ab]	1.51	<0.01	0.40	0.11	0.57
OM digestibility, %	64.89[c]	74.07[a]	73.57[a]	72.85[ab]	69.58[b]	2.08	0.02	0.46	0.15	0.09
NDF intake, lb/day	6.24[b]	4.44[d]	7.18[a]	5.40[c]	7.69[a]	0.48	<0.01	0.48	<0.01	0.03
NDF digestibility, %	39.86[c]	52.66[ab]	56.56[a]	49.72[b]	55.87[a]	2.98	<0.01	0.51	0.06	0.37

[1]Control = 95% corn silage; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test = *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[a-c]Within a row, values lacking common superscripts differ ($P < 0.10$).

at different times and all bags were removed at the same time (0800 hours on day 6 of the collection period). Two nonincubated bags (0 hour) were also prepared for each sample. *In situ* bags containing DRC were rinsed with distilled water and dried at 60°C for 24 hour and then weighed for determination of DM disappearance. Neutral detergent fiber disappearance was determined for *in situ* bags containing corn bran and corn silage by refluxing bags in neutral detergent solution using the ANKOM ²⁰⁰ Fiber Analyzer (Ankom Technology). Dry matter disappearance of DRC and NDF disappearance of corn bran and corn silage within each dietary treatment was calculated by subtracting remaining residue of each sample (24 and 36 hours) from the initial value (0 hour).

Digestibility data were analyzed as a Latin rectangle using the mixed procedure of SAS (SAS Inst., Inc., Cary, N.C.) with period and treatment as fixed effects and steer as a random effect. Main effects of corn silage and MDGS inclusion and the interaction between corn silage and MDGS inclusion were also tested. The interaction was removed from the model due to lack of significance ($P > 0.10$). The mixed procedure of SAS was used for *in situ* data analysis with fixed effects of treatment, time of incubation (24 or 36 hours), and the treatment x time interaction. *In situ* bag was the experimental unit. Steer and steer x treatment were used as random effects in the *in situ* analysis. Ruminal pH data were analyzed as repeated measures using the GLIMMIX procedure with days as the repeated measure, treatment as a fixed effect, and steer as a random effect. Main effects of corn silage and MDGS inclusion and the interaction between corn silage and MDGS inclusion were also tested. To compare to the 95% silage control diet, means across all diets were separated with the pdiff option when the F-test was significant ($P < 0.10$).

Results

There were no corn silage concentration × MDGS concentration interactions for intake and total tract digestibility data ($P \geq 0.40$; Table 2). For the main effect of corn silage inclusion, steers fed 45% corn silage compared to 15% corn silage had increased DMI ($P = 0.07$) and NDF intake (NDFI; $P < 0.01$). There was a tendency for increased OM intake (OMI; $P = 0.11$), decreased DM digestibility (DMD; $P = 0.10$), and decreased OM digestibility (OMD; $P = 0.15$) for steers fed 45% corn silage compared to 15% corn silage. However, NDF digestibility (NDFD; $P = 0.06$) was improved as corn silage increased from 15% to 45%. For the main effect of MDGS inclusion, there were greater DMD ($P = 0.04$) and OMD ($P = 0.09$) and decreased NDFI ($P = 0.03$) for diets containing 20% MDGS compared to diets containing 40% MDGS; there were no differences in DMI ($P = 0.69$), OMI ($P = 0.57$), or NDFD ($P = 0.37$) when steers were fed either 20 or 40% MDGS.

When comparing across all treatments, DMI and OMI was greatest for steers fed 45:20 or 45:40, with steers fed 15:20 and 15:40 being intermediate and not different from 45:40; steers fed the control diet had the lowest DMI and OMI ($P < 0.01$). Digestibility of DM and OM was greatest for 15:20, 15:40, and 45:40; with steers fed 45:40 being intermediate and not different from 15:40; the 95% corn silage control diet had the lowest digestibility of DM and OM compared to all other treatments ($P \leq 0.02$). Intake of NDF was greatest for diets 45:20 and 45:40 ($P < 0.01$). Steers fed the control diet had increased NDFI compared to steers fed 15:20 or 15:40; steers fed the 15:20 diet had the least NDFI ($P < 0.01$). Digestibility of NDF ($P < 0.01$) was greatest for 15:20, 45:20, and 45:40; steers fed 15:40 were intermediate and not different from 15:20. Steers fed the control diet had the lowest NDF digestibility ($P < 0.01$), most likely due to corn silage NDF being less digestible than NDF coming from distillers grains or corn.

There was an interaction between corn silage concentration and MDGS concentration for average ruminal pH ($P = 0.06$; Table 3). When diets contained 15% corn silage, average ruminal pH was slightly decreased as MDGS was increased from 20 to 40% of the diet; however in diets containing 45% corn silage, average ruminal pH increased when MDGS increased from 20 to 40% of the diet. There were no interactions between corn silage concentration and MDGS concentration for maximum or minimum ruminal pH ($P \geq 0.15$). As forage:concentrate ratio is increased in ruminant diets, ruminal pH is usually increased due to less fermentable

Table 3. Effect of corn silage and modified distillers grains with solubles (MDGS) inclusion on pH measurements.

	Treatment[1]						*P*-value[2]			
	Control	15:20	45:20	15:40	45:40	SEM	F-test	Int.	Silage	MDGS
Maximum pH	7.25[a]	6.64[bc]	6.86[b]	6.50[c]	6.94[ab]	0.19	<0.01	0.15	<0.01	0.62
Average pH	6.73[a]	5.69[cd]	6.02[bc]	5.65[d]	6.28[b]	0.19	<0.01	0.06	<0.01	0.12
Minimum pH	5.96[a]	5.01[c]	5.23[bc]	5.06[c]	5.45[b]	0.14	<0.01	0.29	<0.01	0.05

[1]Control = 95% corn silage; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test = *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[a-d]Within a row, values lacking common superscripts differ ($P < 0.10$).

Table 4. Effect of corn silage and MDGS inclusion on corn DM disappearance and corn silage and corn bran NDF disappearance.

	Treatment[1]						*P*-value[2]			
	Control	15:20	45:20	15:40	45:40	SEM	F-test	Int.	Silage	MDGS
Corn bran, % NDFD[3]										
24 hours	41.36[bcde]	36.12[ef]	42.77[cde]	39.52[df]	48.60[bcd]	4.28	0.11	0.73	0.04	0.32
36 hours	59.81[a]	42.17[bcd]	50.82[ab]	43.74[bce]	56.52[a]					
Corn silage, % NDFD										
24 hours	39.72	45.38	35.22	38.96	45.52	11.30	0.98	0.61	0.96	0.81
36 hours	51.16	47.62	40.81	44.55	53.61					
Corn, % DMD[4]										
24 hours	62.05[g]	73.78[ef]	77.72[cdef]	74.06[def]	79.52[bde]	2.83	<0.01	0.93	0.09	0.99
36 hours	71.95[f]	81.11[abcd]	85.43[ab]	80.60[abc]	83.14[ac]					

[1]Control = 95% corn silage; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test = *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[3]Interaction between treatment and time point ($P = 0.03$).
[4]Interaction between treatment and time point ($P = 0.02$).
[a-g]Within each dependant variable, values lacking common superscripts differ ($P < 0.10$).

substrate. In this experiment, as corn silage was increased from 15 to 45%, maximum and minimum pH were increased ($P < 0.01$). When MDGS was increased in the diet from 20 to 40%, there was an increase in minimum ruminal pH ($P = 0.05$), but no difference in maximum ruminal pH ($P = 0.62$). As expected, when the control diet was fed, average and minimum ruminal pH were greater than all other treatments ($P < 0.01$). The control diet maximum pH was not different from 45:40 but was greater than all other treatments ($P < 0.01$).

For the *in situ* disappearance results, a treatment x time interaction was observed for NDF disappearance of corn bran ($P = 0.03$; Table 4). At an incubation period of 24 h, there was increased NDF disappearance of corn bran in 45:40 compared to 15:20 ($P = 0.05$). All other treatment comparisons were not different ($P > 0.10$). At 36 hours, steers fed the control diet and 45:40 had increased ruminal NDF disappearance of corn bran compared to 15:20 and 15:40 ($P \leq 0.02$); however, the control diet and 45:40 were not different for NDF disappearance of corn bran from 45:20 ($P \geq 0.15$). There was no corn silage concentration × MDGS concentration interaction for NDF disappearance of corn bran ($P = 0.73$). Increased corn silage in the diet resulted in increased disappearance of NDF from corn bran ($P = 0.04$).

There was no interaction between treatment and time for NDF disappearance of corn silage ($P = 0.89$). There were no differences between treatments for *in situ* NDF disappearance of corn silage ($P = 0.23$). As corn silage was increased in the diet, DM disappearance of corn increased ($P = 0.09$); however MDGS concentration did not affect DM disappearance of corn ($P = 0.99$). For DM disappearance of corn, there was no interaction observed between diet and time of incubation ($P = 0.32$). Diets containing 45% corn silage had the greatest corn DM disappearance, 15% corn silage diets being intermediate, and the control diet had the lowest corn DM disappearance ($P < 0.01$).

Maximum digestion of feed occurs when the rumen environment is optimum for rumen microbial populations that are most efficient at digesting the substrates offered in the diet. These data suggest increased fiber digestion in diets containing elevated concentrations of corn silage due to a more suitable environment for fiber-digesting microorganisms.

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